

A STUDY OF INDUSTRY - INSTITUTES COLLABORATIVE BEHAVIORS IN INITIALIZATION, COLLABORATION, TRANSFERENCE AND COMMERCIALIZATION STAGE FROM THE TECHNOLOGY READINESS LEVEL

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ABSTRACT

The economic environment is very steep on this moment. The full and effective integrating on the developing capability of government, universities, research institutes and industries will help to speed the innovation to commercialization. Within the efficient cooperation will be able to shorten the product development process and making industrial innovation saving time. It will help industries to create more competence.

This study is base on the point of "Technology Readiness Level ". It discussed the Industry-Institutes collaborative behaviors. The researching objectives are the industrial companies which had the collaboration projects with research institute teams in recent years. Base on the subject matter of the case studies which discussed the four main stages of Industry-Institutes: (Initialization) Technology,(Collaboration) Industry-Institutes collaboration, (Transference) The cognitive gap in collaboration, (Commercialization) The final technical commercialization. The four facets of this study which explore the behavior of Industry-Institutes collaboration to accelerate technology commercialization. The conclusions of this study : (1) Easily accessibility of market and technology information is the key factor to initiate the collaboration between the industrial companies and research institutes ;(2) The common consensus of the Technology Readiness Level is the key factor of successful collaboration; (3) Peer resource input in both companies and institutes is the key element of the technology commercialization;(4) Research institutes help companies to link external marketing resources is the key factor for technology commercialization success.:(5) With the flexible Industry-Institutes collaboration project according to the scale and capability of the companies can increase the chances of success of technology commercialization. Hope that through this study to enhance future Industry-Institutes collaboration to perform the quality implementation of the technology commercialization, competence for both industrial companies and research institutes.

KEYWORDS: *Technology Readiness Level, Industry-Institutes collaboration, Cognitive Gap, Technology Commercialization & Research Institutions*

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INTRODUCTION

Organization for Economic Co-operation and Development (OECD) stated that if the national innovation system is unable to efficient operation of the system itself, assistance is a necessary instrument of Government policy. Taiwan, for example, in government policies in the past, driven by Industry-Institutes collaborative achievements over the years have good growth, academic research results implemented in the industry were still not too high. The gap between the technical development and application of commercialization, making previous

technology developed by the investment couldn't be fully and effectively contributed its economic benefits.

To promote development results of usage should not be to directly narrowed gap for means. In order to avoid effect on academic of independence, basing on the basic academic research to establish the development institutes by government or civil established. Then through the technology added value, it will provide to industry the real need of commodity. The collaboration will effectively shorten the industry in commodity development of time schedule, makes industry innovation being able to toward limitation then create out stronger of international competitiveness.

To improve the quality of Industry-Institutes Collaboration has become important trend of technology development. This research based on the technology readiness level (TRL) for views starting, discussing past many Industry-Institutes Collaborative motivation and behavior. With the deeply interview on related companies to understand the process and final result of Industry-Institutes Collaboration whether produced cognitive gap. Then we tried to find out the solution to shorten the schedule and recognition gap of the Industry-Institutes Collaboration in future. Then helping to accelerate and strengthen the technology to commercial.

Four Stages of Industry- Institutes Collaboration

This research was from nearly five years of the industrial companies which had cooperated with the Research Institute's technical team. Through the deeply interviewing with related to study about industrial companies and research institutes for the cognition of technology readiness level(TRL). To find out the Industry- Institutes collaborative behaviors in the "Initiation, Collaboration, Transference and Commercialization" four stages.

Initiation: Both industrial companies and research institutes were interested in cooperation, and put resources for conducting assessments and cooperation.

Collaboration: Companies and institutes planed for technical cooperation.

Transference: Industry-Institutes collaboration went technology turning into product commercialization process.

Commercialization: Assessment of technology commercialization of results.

Technology is the starting point of Industry-Institutes collaboration. TRL first by NASA (NASA, National Aeronautics and Space Administration) in 1980, developed for the space program review. In the beginning that TRL just only had 7 levels, later expanded to 9 levels (TRL1~TRL9). Then TRL were adopted by the United States Department of Defense for weapon acquired plan review, and establishing major weapons systems to receive TRA mode. To reduce the risk of access, Mankins (1995) defined TRL as "a system of metrics/measurement system in support of specific technology maturity assessments, technical maturity, consistency among different types of standard, described hardware and software technologies maturity."

INO is Canada's largest national institute of industrial optics and photonics product design and development. It took the leading place in the fields of optics and photonics research and development. TRL was also taken as to the last technology commercialization process management on the development of management in technology, concept prototypes, and technology maturity from the definition of TRL1~TR9 (table 1):

Table1: INO TRL Definition

Phase of Development	Level	Description
Exploratory	TRL1	The scientific research phase
	TRL2	The applied research phase
Development	TRL3	Analytical and experimental proof-of-concept for the critical
	TRL4	The component and/or breadboard validation in done in a laboratory environment
	TRL5	A higher fidelity breadboard is validated in the application specific or relevant product implementation environment
α -Test	TRL6	A representative model or prototype of the system(alpha prototype) is tested in the environment of the application
β -Test	TRL7	Demonstration of functionality of an actual prototype(beta system)
Pre-production	TRL8	Pre-production phase
Production	TRL9	Production phase

ITRI also established TRL index consists of a scale of 1 to 9. TRL1, 2 are the basic research. TRL3, 4 are prototype systems. TRL8,9 are mass production technology which is the most difficult research and development phase, also known as the “Valley of Death”.

Industry-Institutes Collaboration

For the research and development capability in enterprises, the high intensity in research and development to warded to collaborative research of University-industry partnerships (Cohen et al., 2002; Schartinger et al., 2002). On an enterprise scale, large corporations tended to take the knowledge transfer and support University-industry partnerships; Small businesses were more likely to take cooperative research and technology transfer of University-industry partnerships (Santoro and Chakrabarti, 2002).

Siegel et al. (2003) proposed different types of enterprise scale, degree of innovation, industry, technical categories which affected all enterprises and academic resources into the technical capability for enterprises’ cooperation. Base on the demand in the industry-university cooperation, companies needed useful technology. This class for University-industry cooperation of manufacturers' demands, were more willingness to establish relations of production-study-research cooperation. Hagedoorn et al. (2000) showed the results of enterprise scale and development oriented to establish the University-industry partnerships.

Till now, Industry-Institutes collaboration approach still has no uniform classification. Peters and Fusfeld (1982) classified the University-Industry cooperation into formal and informal, long-term and short-term cooperation, cooperation and interaction in simple and complex ways. OECD (1999), divided into seven types: (1) General research support: the enterprises set up a Fund, donating devices and other research facilities assistance to academics in various studies; (2) Informal cooperation research: academic researchers sign the cooperation contract with industry without the school pipeline; (3) Contract research: the industry in order to reduce investment in research and development, to be part of research and development activities to contract outsourcing; (4) Knowledge transfer and training programs: through collaboration, on academic research and development meeting, business of academic research and development topics; (5) Participate in government-funded joint research projects: collaboration made by the Government-funded research to develop industry’s relationship with institutes; (6) Research contact Alliance: industry, academia and the research institutes

into a research and development team; (7) Joint Research Centre: the academic resources which integrate schools and institutes, strengthen basic research and applied research capability.

Research Objects

This research aimed on the companies which had the Industry-Institutes collaboration in the last five years to understand their related behaviors. Then selected and screened the related collaboration in the four stages for researching. We found that some cases that had suspended the collaboration during the “Collaboration” or “Transference” stage. Through the deeply interviewing, we selected four collaboration cases and found that two of them had the good feedback for the technology commercialization. One felt that the final result couldn’t meet their original expectation, so it won’t enter into the commercialization stage and stop in the “Transference” stage. One found that final result still lacked something to go to commercialization and the institute couldn’t improve their performance for their requirement. Finally the company sought the support from third-party to accomplish the commercialization base on the original result. Compared to these four cases in the four stage’s related behaviors, the study summarized the key points to provide the direction for Institutes to promote their core technology to have the Industry-Institutes collaboration in the future. Helping institutes to improve the quality of the Industry-Institutes collaboration. We outlined the basic data of these four cases such as (table 2).

Table 2: Company and Institutes Collaboration List

Case	1	2	3	4
Company team	A	B	C	D
Industry	Chanel	Chanel	ICT	Precision Instrument
Institute team	W	X	Y	Z
Collaboration item	3D Printer	Cloud office	Wearable device	Electron Microscope
Commercialization	Yes	Yes	No	Yes
Company satisfaction	High	Low	Low	High
Institute satisfaction	High	Middle	Low	High

Disclosure

This study had deeply interviewed four companies which had the Industry-Institutes Collaborative program with ITRI. TRL is as a starting point for approaching the companies and research institutes’ collaboration behavior and related recognition on the four stages. Study found as follows:

Initialization: Both industrial companies and research institutes will address the needs of future market trends and its own developments, began to look for partners for cooperation. They will collect the information on core competence of partner's internal and external assessments for evaluation. Then it will consider about whether had collaboration in the next stage. The study found that companies and institutes in the "Initialization" has the following characteristics in the process.

- Technology information easily access of industrial companies from research institutes is the key beginning point of both cooperation.
- Technology terms are too professional to understand is the resistance in cooperation.
- Industrial companies revealed their future plan will be the key factor that appealed research institutes to visit to discuss the technology.

- The initial points of Industry-Institutes collaboration are the research institutes' TRL and the common cognition of future market needs.

Collaboration: According the evaluation of above "Initialization", both companies and institutes will begin for real cooperation. They will set up the output subject schedule. They will also evaluate the future return of investment (ROI). If both can reach consensus in this stage, the future technology commercialization of success chances will be high. The study found both in "Collaboration" has the following characteristics in the process.

- The ROI is the key concern issue of companies on Industry-Institutes Collaboration.
- The smaller of cognitive differences in outcomes for both, the higher success rate of technology commercialization in the future
- Target market of the collaborative output was the key considerations of setting the technological specification in Industry-Institutes Collaboration.
- Both put the human resource to form a team and the atmosphere of interaction and cooperation are key elements of success
- Both of high level commitment is the key factor of cooperation able to start.

Transference: According to "Collaboration" of cooperation process and the output results, both will prepare to start for technology commercialization of work. They may have the cognitive differences for cooperation output. If both can amend the definition of the output according to the current market competition status in this stage, and eliminating both cognitive differences, then it will have chance to enter into technology commercialization. The study found both in "Transference" has the following characteristics in the process.

- Companies hope that the research institutes not just only deliver the research results, but also can help companies of commercial promotion.
- If institutes can't be completed within the time limit in accordance with the companies' original expectations, companies would seek assistance from other institutes or suspend cooperation.
- In response to changes in market demand and competition. If both can have the improvement or compromise in the technology transfer process, it will increase the possibility of successful technology commercialization.
- Institute has the dedicated staffs to handle with the market information and communication with companies to eliminate cognitive gap in the collaboration team are the important key factors for technology commercialization.

Commercialization: According to the output of the cooperation, both will start to promote the related commercial activities. Although the main task is on company itself, but if research institutes can assist companies for commercial promotion, such like holding seminar or common media exposure. It will increase commercialization success of chances, and increase companies' satisfaction. It may have the opportunity for next collaboration. The study found in "Commercialization" has the following characteristic.

- Although companies lead the technology commercialization of product promotion, if institutes can help companies to promote commercial activities, it will increase technology commercialization success rate.

- Institutes help companies acquire external resources such like government subsidies will increase both satisfaction
- Technology commercialization results will affect the willingness of Industry-Institutes Collaboration.

CONCLUSIONS

This research focuses on TRL as a starting point to discuss Industry-Institutes Collaboration. With a view to improving future results and quality of Industry-Institutes Collaboration, then help to realize the technology commercialization. It will increase the competitiveness for both companies and institutes. This research through the four stages of Industry-Institutes collaboration of the various phases of the following conclusions:

- The easily accessible of market and technology information is the key to start the Industry-Institutes collaboration

Research institutes focused on technology development. They often make the technical terms too professional. The industrial staff is looking for cooperation in the development of products often didn't know where to look for sources of technology. Technology developers usually too focused on "technical nature" and neglecting the technology and market linkage of "application characteristics", so both will have a great gap at last.

- The common cognition of TRL in both industrial companies and research institutes is the key of successful Industry-Institutes collaboration.

One effect of Industry-Institutes collaboration is to shorten development schedule in the industry. Making industry innovation can towards limitation then created out stronger of international competitiveness. Industrial companies usually will select in technology team of TRL "7" for cooperating, but due to both for each other of TRL of cognitive defined differences, makes cooperation of output inconsistent both expected. When TRL arrived "7", it's very difficult to do the fundamental changes. So it is often hard to meet the industry's needs.

- Both companies and research institutes peer resources input is the key factors for technology commercialization.

Due to the cognitive differences in "Technology" between companies and institutes on the early cooperation stage, both peer input through human and material, in the course of cooperation gradually reduce the cognitive differences. That will increase the chances of success to technology commercialization for Industry-Institutes collaboration.

- Research institutes help industrial companies to link external marketing resources is the key factor for successful technology commercialization.

Usually the research institutes have the resources for the global linkage. They also hold or attend the global technology seminar and published related of technology file. It can assist companies during the process for technology commercialization. It let companies get better of market feasibility. It will increase companies in follow-up commercial success of opportunities. Through the both common promoting of technology commercial results, it can make both have more of trust on each other, and conducive to future cooperation again.

- According to companies' size and capability, providing the flexible Industry-Institutes collaboration projects will increase chances of success in technology commercialization

As each the scale of the company size and good at marketing or R&D strengths is different, so take the flexibility of Industry-Institutes collaboration projects to suit different scale and characteristics of the industrial companies can increase the chances of success in technology commercialization

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